3. Apparatus of Neumann[1] and Le Roux.[2]

II. Estimation of the velocity of sound by the number of vibrations and the wave-length of musical sounds.

A. Direct methods:—

1. Method of Bernouilli, with sonorous tubes.
2. Method of Chladni,[3] with rods.
3. Method of Kundt.
4. Methods of Stefan[4] and Warburg.[5]

B. Methods based on the interference of sonorous waves:—

1. Method of Savart.[6]
2. Method of measurement of the wave-length with Quincke's interference tubes.[7]
3. Method of Zach.[8]
4. Method of beats.

The way in which the velocity of sound is affected by certain circumstances, especially intensity and pitch, requires further elucidation. Up till recent times it was believed, in accordance with the earlier observations and the theoretical formulæ of Newton and Laplace, that sound is propagated with a uniform velocity in the same medium, the temperature remaining constant; that the velocity of sound in air at zero, *e.g.*, is an invariable quantity. After an observation by Parry related by Sir James Ross, that the sound of a cannon was always heard sooner than the word of command to fire, Schröder van der Kolck was led by theory to a formula giving the velocity of sound in a gas as a function of the relation of the two specific heats and the degree of compression of the medium. This velocity would be greater the more intense and grave the sound, and would diminish with the distance traversed.

Regnault set himself to determine rigorously the ratio of the two specific heats of gases, with a view to deducing the mechanical equivalent of heat. He remarked that Newton and Laplace had assumed, in their formulæ, that the gases were perfect, *i.e.* (1), that they followed Mariotte's law exactly; (2) that their elasticity was not altered by surrounding bodies; and (3) that gas opposes no inertia to the transmission of sound-waves. Accordingly the propagation of sound was supposed the same whatever the intensity. Regnault's more complete formula indicated that the velocity is greater the greater the intensity of the wave.

Experiment proved that the intensity of the wave diminishes in a tube more rapidly the smaller the section. The wave is weakened by the reaction of the elastic walls of the tube, causing a considerable loss of *vis viva*; and the diminution of intensity, according to Regnault's formula, should result in diminution of velocity, which diminution must be more rapid the narrower the tube. This was confirmed by experiment.

As regards experiments with the human voice and wind-instruments, the following are the principal observations of Regnault; acute sounds are propagated with much less facility than grave sounds; in very wide pipes, it is necessary to sing with a baritone voice in order to be well heard; the fundamental sound is heard before its harmonics, which succeed in order of pitch, and the timbre is thus altered. The velocity was found independent of pressure, as indicated by the formulæ. Lastly, with different gases, the velocities are inversely proportional to the square roots of the densities.

In connection with the foregoing, it is interesting to compare the results that have been obtained by Kundt.[9] The idea of his method was suggested by Chladni's figures. A tube of glass is used about 2 m. long, containing a certain quantity of lycopodium powder (distributed as regularly as possible), and closed at the two ends. You rub the tube longitudinally, so as to produce a sound. The powder is then seen to accumulate at the nodes of vibration, so that the sonorous waves of the gas are, in a way, rendered visible. The distance from one node to the next being half a wave length, suppose that we have twelve in the tube; the length of the tube vibrating transversely, will be the half of a wave-length in the *glass*. Under such conditions, then, the length of half a wave in the glass is sixteen times the length of half a wave in the air. It will follow that the velocity of sound in the glass is sixteen times that in air. Other gases may be used in the tube, and the velocity of sound similarly found in them.

By a simple modification of the apparatus, this method gives the velocity of sound in a large number of solid bodies, and the results agree pretty closely with those found by different methods.

But Kundt's method does not give sufficient precision in respect to the delicate questions investigated by Regnault. The wave-lengths measured never go beyond about 45 mm., making the 0·0001386 part of the course traversed by sound in a second; hence an error of 0·1 mm. made in the measurement of a wave-length would lead to an error of $\frac{11}{16}$ m. in the result sought. With this reserve, Kundt's results may be here noted.

1. The length of sonorous waves, and consequently the velocity of sound, diminishes proportionally to the diameter of the tube, when this is less than a quarter of the length of undulation.

2. In narrow tubes a high sound is transmitted more rapidly than a grave one, and the diminution of the velocity of sound is in inverse ratio to the wave-length.

3. The velocity of sound is independent of the pressure in a wide tube, but increases with it in a narrow one.

It will be seen that these latter results are in contradiction with those found by Regnault.

It may be generally affirmed that every influence which tends to increase the *vis viva* of the molecules of the sonorous medium has an accelerating action on the velocity of sound, and every influence tending to diminish the *vis viva* diminishes also the velocity.

The causes affecting the velocity of sound are (it is shown) various. *In an indefinite medium* they are:—1. The temperature of the medium; 2. The quantity of foreign substances found in it, *e.g.*, water-vapour; 3. The pitch of the sound; 4. The direction and force of the wind; 5. In solid bodies, the direction of the sound in relation to the molecular structure.

In sonorous tubes:—

6. The diameter; 7. The curvature; 8. The rugosity of the interior surface; 9. The thickness of the walls.

The action of the following additional causes is still disputed:—

1. The intensity of the sound; 2. The length of course traversed; 3. The substance forming the tubes.

There is complete disagreement between Regnault, Schröder, Kundt, and Seebeck, as regards the influence of the pitch of the sound. Regnault affirmed merely that an acute sound is transmitted more easily, but not more rapidly, than a grave sound; Schröder finds that the velocity diminishes as the acuteness increases; Kundt and Seebeck reach the contrary result. Fresh experiments are required to settle this important question.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

A NEW supplemental charter having been granted to the University of London a few months since, on the joint application of the Senate and of Convocation, empowering the Senate to admit women to graduate in its several faculties (Arts, Science, Law, Medicine, and Music), on such conditions as the Senate, with the concurrence of the Home Secretary, should deem expedient, the Senate lost no time in passing a resolution which made all the existing regulations, relating not only to graduation, but also to the various honours and rewards granted at the several examinations open to female as well as to male candidates. This resolution having been now approved by the Home Secretary, female candidates will be admitted forthwith to the matriculation examination; and all such as have already passed the general examination for women will be considered as having matriculated, and will be admissible (after the required interval) to the first degree examination in either of the faculties. Further, with a view to the special encouragement of female candidates desiring to go through a regular academical course, the trustees of the Gilchrist Educational Trust have instituted two exhibitions, one of 30*l.*, the other of 20*l.*, per annum, tenable for two years, to the female candidates who pass highest in the honours division at the matriculation examination; and two exhibitions, one of 40*l.*, the other of 30*l.*, per annum, tenable for two years, to the female candidates who pass highest at the first B.A. examination (provided that they obtain in the first case two-thirds, and in the second three-fifths, of the total number of marks), to assist them in pursuing their studies at some collegiate institution approved by the trustees; with the further reward of a gold medal of the value of 20*l.* (or of a book-prize of the same value) to the female candidate who passes highest at the second B.A. examination, if she obtains not less than two-thirds of the total number of marks. These rewards are quite independent of those granted

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[1] *Pogg. Ann.*, t. xcii. p. 485.

[2] *Comptes Rendus*, t. lv. p. 609.

[3] *Pogg. Ann.*, t. cxxviii. p. 307.

[4] *Comptes Rendus*, t. lv. p. 662.

[5] Chladni's "Acoustics."

[6] *Sitzungsberichte der Wiener Akademie*, t. lvii. pp. 197 and 708.

[7] *Pogg. Ann.*, t. cxxxvi. p. 285.

[8] *Comptes Rendus*, t. vii. p. 1068.

[9] *Pogg. Ann.* t. v. p. 496.

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by the University, and may be held in conjunction with them. Further particulars may be obtained by application to the Registrar of the University, London, W.

SCIENTIFIC SERIALS

Annalen der Physik und Chemie, No. 7, 1878.—Theory and experiment having given different results for the heat-conduction of certain (polyatomic) gases, Prof. Wüllner supposed the reason to be that the values were not comparable, because they related to different temperatures. He shows from experiment that the ratio of the two specific heats varies with the temperature. For those gases whose specific heat at constant pressure does not vary with the temperature, the variation is of about the same order as the divergence of gases from Mariotte's law. For gases, whose specific heat varies with the temperature, the ratio of the specific heats varies in a greater degree, and approximately so that the difference of the specific heats at 0° and 100° is constant. Herr Wüllner finds here an explanation of the discrepancy.—In a lengthy paper Herr Hittorf vindicates the affirmation that "electrolytes are salts," in reply to Dr. Bleekrode's criticism. We note, also, papers on the energy of reciprocal action, by Herr W. Weber, and on the law of storms, by Herr Schröder.

No. 8.—This number opens with a paper by Herr Herwig, on the amount of electricity required for full charge of a condenser platina water-cell, and on the distance of the molecules in liquid water. The upper limit he deduces for the latter is 0·186 millionth mm.; which agrees well with other determinations, Lorenz 0·1 millionth mm., Thomson (for lower limit) 0·05. He finds in the result a confirmation of the hypothesis of rotatable electrolytic molecules.—In a paper on the wandering of ions, M. Kirmis shows that the amount of transference of copper from the solution of its sulphate salt increases with decreasing concentration.—Investigating the history of the invention of the pendulum clock Herr Gerland considers that Bürgi and Treffler have not the least claim to this merit. It belongs to Galileo and Huyghens, who made the discovery independently. As the former, however, came on it fifteen years earlier, the pendulum clock is properly his work.—Herr Auerbach endeavours to show that Grossmann's vowel theory applies not to actual vowels, but to typical ideal clangs, and when the changes thus rendered necessary are introduced into it, it affords, if not incorrect results, nothing new as against Helmholtz's theory.—Herr Bauer has a paper on summation tones as difference and beat-tones from the over-tones of the primary tones; and Herren Nilson and Pettersson write on the production and valence of beryllium.

Journal de Physique, August, 1878.—In this number M. Bouty explains the construction and use of electric diagrams, for representing as completely as possible all the peculiarities of an electric field.—Some curious experiments with the electric tourniquet are described by M. Bichat.

SOCIETIES AND ACADEMIES

PARIS

Academy of Sciences, September 9.—M. Fizeau, president, in the chair.—The following papers were read:—On some phenomena of a vaso-motor action observed in the course of researches on the physiology of the excito-secretive nerves, by M. A. Vulpian.—On some new effects produced by the telephone, by M. du Moncel.—On the new palæozoic group of Dolerophylleæ, by M. G. de Saporta.—On a new gyroscopic apparatus, by M. Gruey.—On the accumulation of magnetism on the summit of hemispheric poles, by M. L. Romain.—On the waves of the high sea, by M. Ch. Antoine.—Some notes, by MM. Vasseur, Lassalle, and Cameron, regarding aerial navigation.—An additional paper by M. Giraud respecting the treatment of cholera.—A note by M. F. Bettelhauser respecting the various means employed for the destruction of phylloxera.—Prof. Asa Gray, who has been nominated a correspondent of the Botanical Section, presented the first part of his "Synoptic Flora of North America."—Rectification of the position previously assigned to the new planet discovered during the eclipse of the sun on July 29, by Prof. J. Watson, and note on the observation of a second star seen under the same circumstances.—On a new method to decompose numbers into square binary sums and its application to indetermined analysis, by M. E. de Jonquières.—On the depression which, at the surface of a horizontal elastic and isotropous ground, is produced by a weight deposited thereon, and on the distribution of this weight between its various points of support, by M. J. Boussinesq.—On the variations of intensity which take place in a current if the pressure between the two contacts, which complete the circuit is modified, by M. Treve.—On the application of the telephone to the determination of the magnetic meridian, by M. H. de Parville.—On the constitution of the inactive glucose of crude cane sugar and molasses, by M. U. Gayon.—Comparison between the *Balaena* (*Macleayius*) *australiensis*, of the Paris Museum, and the *Balaena biscayensis*, of Naples University, by M. Fr. Gasco.—On the reproduction of the *Hydra*, by M. Korotneff.—On the comparative structure of *Lepidodendron* and *Sigillaria*, by M. B. Renault.

VIENNA

Imperial Academy of Sciences, July 18.—Critical researches on the species of the natural family of the stags (Cervi), (third part), by Dr. Fitzinger.—Influence of temperature on the galvanic conductivity of liquids, by Drs. Exner and Goldschmiedt.—On some new or imperfectly-known fish-species, by Dr. Steindachner.—On the Orthoptera of Istria, by Dr. Kraus.—On new Cymothoides, by Herr Kölbel.—On the form of spark-waves, by Prof. Mach and Herr Weltrubsky.—The origin of tubes in the Nostoc-colonies in Blasia, by Herr Waldner.—Influence of the density and the temperature on the spectra of vapours and gases, by Herr Ciamician.—Action of chloroform and ether on respiration and circulation of the blood, by Dr. Knoll.—On Roussin's binitro-sulphuret of iron, by Herr Demel.—On a new method of quantitative investigation of gold and silver alloys, by Herr von Jüptner.—On the spinal ganglia and cord of Petromyzon, by Herr Freud.—Rocks from Greece, by Herr Becke.—On nitrocuminol and its derivatives, by Prof. Lippmann and Herr Strecker.—On compounds of nickel and cobalt chloride with tar bases, by Prof. Lippmann and Herr Vortmann.—On the Malabrian kinogumi, and a new substance got from it, kinoïn, by Herr Etti.—On Borneo camphor, by Herr Kachler.—On cinchonidin, by Herren Skraup and Vortmann.—Action of water on the haloid compounds of alcohol radicals, by Herr Niederist.—On the geological formation of the western part of Central Greece, by Prof. Neumayr.—On the geological formation of the island Eubœa, by Dr. Teller.

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